

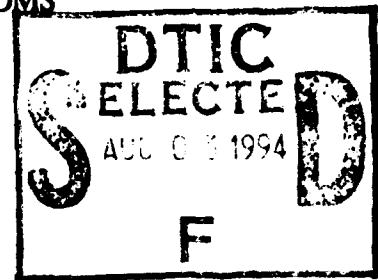


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## MATTER-WAVE INTERFEROMETRY WITH LASER COOLED ATOMS

David McIntyre, Oregon State University, Corvallis, OR 97331

Summary Questionnaire, 27 May 1994



## 1. Research Description:

This program is investigating matter-wave interferometry with laser cooled atoms. A slow beam of laser cooled rubidium atoms will be used as the matter-wave source. The atom optical elements are microfabricated amplitude transmission gratings which will be used in a three-grating interferometer to split and recombine the rubidium beam. The interferometer will be a useful new tool for precision atomic physics and a sensitive inertial sensor.

## 2. Scientific Problem:

The principal tasks in this research program are production of a laser cooled rubidium atomic beam, fabrication of submicron amplitude transmission gratings, and construction and testing of the atomic interferometer. Several technical issues must be addressed in each task. The atomic beam must have high brightness to ensure adequate signal to noise ratio and a low temperature to ensure a long coherence length. The gratings must be phase coherent over their area so that the interferometer fringes are not washed out. The interferometer must be vibration isolated so that the fringes do not move appreciably during the signal integration time. Once these technical issues are resolved, the atomic interferometer will be a useful new tool with which to perform precision experiments in atomic physics, quantum optics, and gravitation.

## 3. Scientific and Technical Approach:

This research program takes advantage of and incorporates three new technologies. A beam of slow rubidium atoms is produced by combining the techniques of chirped laser cooling, optical molasses, and magneto-optic trapping. Atoms in a thermal beam are slowed using chirped laser cooling and are loaded into a magneto-optic atomic funnel which reduces the temperature to less than 1 mK and directs the atoms into an intense, slow beam. The rubidium cooling transition

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at 780 nm is excited with commercial diode lasers which are frequency stabilized using optical feedback from diffraction gratings. The cooled rubidium beam has a de Broglie wavelength of 0.5 nm. The interferometer design is similar to the three-grating Bonse-Hart interferometer used in neutron interferometry, and will use amplitude transmission gratings fabricated with high-resolution electron-beam lithography. The combination of laser cooled atoms and microfabricated gratings will allow for a compact and stable interferometer design.

#### 4. a. Progress:

In the past year we have loaded atoms from a laser cooled atomic beam into our two-dimensional magneto-optic trap or atomic funnel. The funnel is comprised of a two-dimensional magnetic quadrupole field in which three mutually orthogonal pairs of counterpropagating laser beams intersect. Two of these pairs are at 45° with respect to the funnel axis and have frequency shifts that impart a small drift velocity to the atoms along the funnel axis. The atoms are thus ejected from the trap with a controllable velocity. We have placed a resonant standing wave probe downstream to detect the atoms leaving the trap. Time of flight experiments show that the atoms have velocities from 6 to 8 m/s. Transverse spreading of the slow atomic beam indicates a transverse temperature of 500  $\mu$ K or less. The flux of atoms in the slow beam is approximately  $5 \times 10^8$  atoms/s.

#### b. Special Significance of Results:

Our atomic funnel is only the third of its kind to be developed. It differs slightly from the others which have been demonstrated. There was some concern that our use of three independent lasers would be a problem; lack of coherence between the lasers can undermine some of the cooling forces. Our frequency offset locking techniques appear to be sufficient to avoid these problems.

#### 5. Extenuating Circumstances:

None

6. Publications:

1. Stabilized Diode-Laser System with Grating Feedback and Frequency-Offset Locking (J. J. Maki, N. S. Campbell, C. M. Grande, R. P. Knorpp, and D. H. McIntyre), Opt. Commun. 102, 251 (1993).
2. Optically Stabilized Diode Laser using High-Contrast Saturated Absorption (C. J. Cuneo, J. J. Maki, and D. H. McIntyre), 1993 Interdisciplinary Laser Science Conference (ILS IX), Toronto, Canada, October 3-8, 1993; Bull. Am. Phys. Soc. 38, 1714 (1993).
3. Optically Stabilized Diode Laser using High-Contrast Saturated Absorption (C. J. Cuneo, J. J. Maki, and D. H. McIntyre), Appl. Phys. Lett. 64, 2625 (1994).
4. Rubidium Atomic Funnel for Atom Interferometry (T. B. Swanson, J. J. Maki, N. S. Campbell, and D. H. McIntyre), Technical Digest of the 1994 International Quantum Electronics Conference, Anaheim, California, May 8-13, 1994, p. 37.

7. Unspent Funds:

I do not expect any unspent funds.

8. Other Government Support:

none

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